

Effect of Waterfowl (*Anas platyrhynchos*) on Indicator Bacteria Populations in a Recreational Lake in Madison, Wisconsin

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A public swimming beach in Madison, Wis., experienced intermittent high fecal coliform counts during the late summer and early fall of 1978. Public health officials closed the beach on a number of occasions. A public health survey identified a combination of waterfowl wastes and meteorological events as the explanation for the high bacteria counts. Fecal coliform bacteria were deposited by mallard ducks and multiplied in the beach sands. The bacteria were subsequently transported into the lake and resulted in high fecal coliform counts in the swimming area.

Vilas Park beach, located on Lake Wingra, Madison, Wis., has experienced unusually high concentrations of fecal coliform organisms during the late summer and early fall. The high fecal coliform levels have resulted in beach closings during the period of greatest recreational pressures.

The Vilas Park beach is approximately 140 m in length and extends onto land about 30 m from the edge of the water. About one-half of the area is sand, and the remainder is grass. The sand is replenished by the City of Madison each spring since there is no natural source. The contained swimming area is 100 m wide and extends 50 m from the shore. The beach is heavily used, particularly on weekends and during hot weather. The annual beach census approaches 100,000 people.

The City of Madison Health Department routinely performs fecal coliform analyses of the waters adjacent to the beach with methods outlined previously (10). The results for 1978 are shown in Fig. 1. Each bar on the graph represents the geometric mean of samples taken during each 1-week period from April through October. In accordance with the National Technical Advisory Committee (U.S. Public Health Service) guidelines, the beach was closed when the geometric mean of the fecal coliform counts exceeded 200/100 ml or when any individual samples exceeded 400/100 ml (5). Weeks during which at least one sample had counts exceeding 400/100 ml are represented by bars with diagonal lines. Arrows signify those weeks during which significant weather events occurred, i.e., those with rainfall of more than 1.2 cm/day or

when onshore winds exceeded 20 mph for at least 3 h/day. The pattern of late summer and early fall high fecal coliform counts is particularly apparent. It can also be noted that almost all of the high peaks are associated with weather events. The numbers in the arrows shown in Fig. 1 represent the same weather events shown later in Fig. 3.

Four sampling trips were made in 1978 and consisted of several locations established around the lake. These surveys indicated that the high bacterial counts were primarily restricted to the immediate beach area, with a rapid decrease occurring within a few hundred meters from the shore (Fig. 2). Occasional high fecal coliform counts were also encountered at one end of the lake near Duck Pond Creek, which is a spring-fed area where many mallard ducks (*Anas platyrhynchos*) reside throughout the year and are partially sustained by food left by local citizens.

Dye tracer studies of local sewer lines near the beach area failed to locate any sewer leakage. Also, a nearby municipal zoo was surveyed and found to be fully sewered, thereby discounting the animal holding areas as immediate sources of fecal coliform bacteria. Dogs and cats are specifically barred from the entire park by a strictly enforced local ordinance. Rodents are not known to inhabit the beach area.

Approximately 100 to 200 mallard ducks reside more or less permanently in the beach area and were hypothesized to be the probable cause of the beach pollution, but literature on waterfowl contamination of beaches is sparse. Waterfowl contamination, by definition, is included in the bacterial indicator systems used for beach

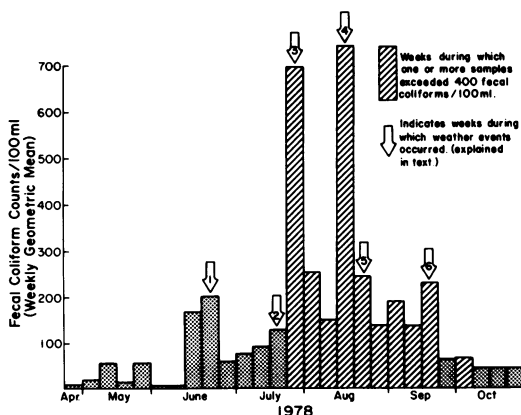


FIG. 1. Weekly geometric means of fecal coliform counts at Vilas Park beach for the 1978 swimming season.

closings (8). However, when the current beach closing criteria were established, little attention was given to differentiating the source of fecal contamination (5, 7, 8, 14). It is known that animals, including waterfowl, are capable of contaminating surface water (6, 7, 9, 13, 15, 17, 18). Ducks have been specifically implicated in contamination of non-recreational waters, such as shellfish areas and wildlife refuges (1-3, 16, 17).

To test the mallard duck contamination hypothesis, we examined the ratios of fecal coliforms to fecal streptococci. The ratios from samples collected in the beach area were calculated and plotted versus time for the period from May through September 1978 (Fig. 3). During the late summer and early fall, the ratios were often below 1.5 and frequently below 0.7, indicating that livestock or poultry (waterfowl) were the most likely source of pollution (4). Once again, the low ratios were associated with meteorological events and occurred during periods of high fecal indicator bacteria counts.

The beach sands and nearshore sediments were examined for indicator organisms. High counts of fecal coliform and fecal streptococcus bacteria were found (Table 1). The ratios of fecal coliforms to fecal streptococci again indicated that livestock or poultry (waterfowl) were the probable source of pollution.

The beach sands were also examined to determine their ability to support coliform bacteria populations. A sterilized composite sample (4 kg) of wet beach sand was inoculated with freshly isolated fecal coliform organisms diluted by a factor of 10^4 from a log-growth-phase nutrient agar slant. The sand was held at ambient temperature (20 to 22°C) in the laboratory in a porcelain pan with a loose-fitting cover. The sand was mixed daily with a sterile spatula. The

number of fecal coliform organisms per 100 g of sand was determined periodically and plotted versus time (Fig. 4). The data indicate that organisms not only survived in the sand but multiplied rapidly during the first week. Further studies of the sand and nearshore sediments indicated the presence of sufficient nutrients that are capable of supporting microbial growth and that these nutrients could be leached from the beach sands (Table 2).

Mallard ducks can contribute daily fecal coliform counts equal to two humans (18). Due to reproduction success and minimal harvest, the number of resident mallard ducks in the Vilas Park beach area increases dramatically by late summer. The ducks frequently defecate onto the beach sands. As shown experimentally, fecal bacterial organisms introduced onto the sands with this fecal material multiply and are carried into the water, primarily by rain runoff, wind erosion, and also the actions of swimmers. The counts in the water become significant in the late summer as the duck population increases (Fig. 1).

The public health significance of waterfowl (e.g., ducks) fecal pollution must be assessed.

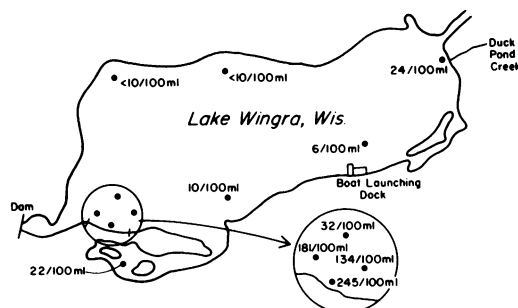


FIG. 2. Fecal coliform counts (geometric means) for various sampling sites on Lake Wingra, Madison, Wis., late summer and early fall, 1978.

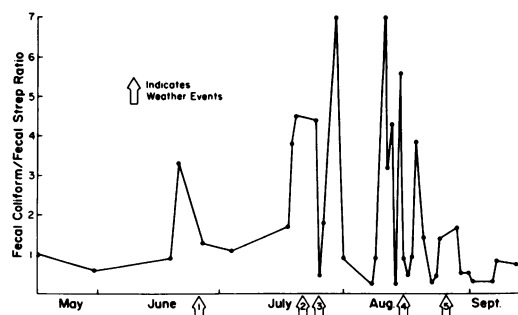
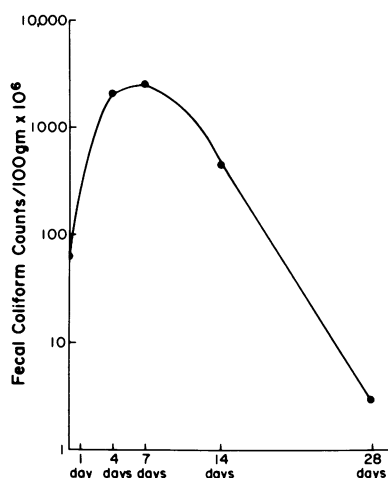


FIG. 3. Ratios of fecal coliforms to fecal streptococci for samples taken at the Vilas Park beach during the 1978 swimming season.

TABLE 1. *Fecal bacteria indicator counts in beach sand and nearshore sediments in beach area*

Date	Location	Counts/100 g		FC/FS ratio
		Fecal coliforms (FC)	Fecal streptococci (FS)	
9/22/78	Center beach	330	2,900	0.11
9/27/78	Center beach	9,000	Overgrown	
9/27/78	Right beach	2,700	Overgrown	
9/28/78	Left beach	990	500	1.8
9/28/78	Beach near grass	670	9,000	0.07
10/10/78	Nearshore sediment	37,000	Overgrown	
10/11/78	Nearshore sediment	11,000	Overgrown	
10/12/78	Nearshore sediment	2,700	Overgrown	

FIG. 4. *Fecal coliform growth curve determined in sterile beach sand inoculated with a recently isolated fecal coliform organism.*TABLE 2. *Nutrients in Lake Wingra, Madison, Wis., nearshore water and nutrients leached from beach sand*

Nutrient	Nutrients in Lake Wingra nearshore water (mg/liter)	Nutrients leached from sand (mg/100 ml of leaching solution per 100 g of sand) ^a
Total P	0.04	0.724
Soluble reactive P	<0.004	0.0034
NH ₃ - N	0.26	<0.02
NO ₂ + NO ₃ - N	0.15	<0.02
Total organic N	0.8	0.94
Total organic C	10.0	30.0

^a Lake Wingra nearshore water used as leaching solution.

The most common human health hazard associated with ducks is swimmer's itch, or echinostoma revolutum (12). The duck tapeworm can also occasionally infect humans (4). Ducks have often been implicated as carriers and disseminators of *Salmonella* (1, 3, 11, 12, 16, 17). The

occurrence of these zoonoses indicates that fecal contamination from ducks is a human health hazard and that beach closings based on the presence of high counts of fecal coliform indicator bacteria are warranted. Future surveys aimed at detecting the possible presence of *Salmonella* in the Vilas Park beach area are indicated.

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